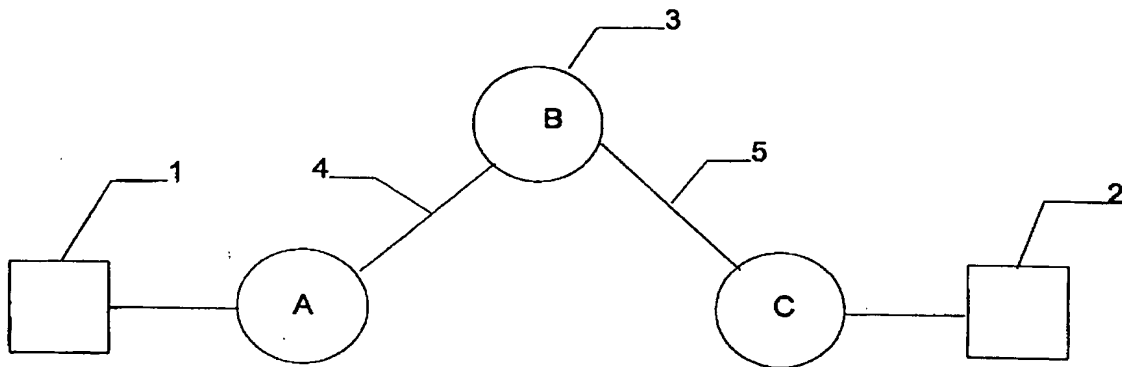


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(51) Int.Cl.<sup>6</sup> H04L 12/26, H04L 12/56  
(54) **MESURES DES DELAIS DES PAQUETS**  
(54) **PACKET DELAY MEASUREMENTS**



(57) L'invention concerne une méthode de mesure du délai des paquets dans un réseau à commutation par paquets. Il s'agit de mesurer le temps de file d'attente pour chaque paquet à chaque noeud d'une connexion à travers le réseau. Les méthodes statistiques sont utilisées pour déterminer une valeur représentative à chaque noeud, puis ces valeurs sont additionnées sur toute la connexion. Une valeur représentant le temps de transmission et le temps de commutation est alors ajoutée à la somme des valeurs représentatives.

(57) A method of measuring packet delay in a packet switched network involves measuring the queuing time for each packet at each node on a connection through the network. Statistical methods are used to determine a representative value at each node, and these values are summed across the connection. A value representing transmission delay and switching delay is then added to the summed representative values.



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# ABSTRACT OF THE DISCLOSURE

A method of measuring packet delay in a packet switched network involves measuring the queuing time for each packet at each node on a connection through the network. Statistical methods are used to determine a representative value at each node, and these values are summed across the connection. A value representing transmission delay and switching delay is then added to the summed representative values.

### Packet Delay Measurements

This invention relates to a method of measuring the delay of encountered by packets passing through a packet-switched network.

A packet network traditionally comprises a series of intermediate nodes that forward individual data packets to the next node along the route until the packets reach their destination. Measuring the delay encountered by data frames as they are traverse through such packet networks, such as frame relay networks, traditionally has been solved by several methods. One such method involves occasionally sending a test packet, or ping, through the network. The packet is returned, back through the network, to the sender when it reaches the receiving node, and the sending node uses the time elapsed between sending and receiving the packet to give an indication of the network delay. Another method is to add timing information, which can be used by the receiving node to determine network delay, into the packet itself.

While the two methods cited above can give indications of delay, they have shortcomings. For example, the ping method suffers from numerous limitations including the fact that the size of the ping packet likely does not match a given data frame's size and that it is sent at a different instant in time than the data frame. It may therefore have a different delay associated with it, and more seriously, the ping packet may not follow the same route as a user data frame, again resulting in a different network delay value.

The second method of adding timing information into the packet results in a proprietary implementation that would not work in standards based networks, such as frame relay networks.

An object of the invention is to alleviate these problems.

According to the present invention there is provided a method of measuring packet delay in a packet switched network comprising the steps of measuring the queuing time for each packet at each node on a connection through the network; applying statistical methods to determine a representative value at each node; summing said representative values across the connection; and adding to said summed representative values a value representing transmission delay and switching delay.

The delay of a packet through a packet network is the summation of the time it takes for the packet to traverse each physical link of the network ( $T_{\text{transmission}}$  for each link), which is a function of the line speed of the link and the packet size, plus the switching delay incurred when the packet is moved from one physical link to another through the network ( $T_{\text{switching}}$  for each switch) normally a constant value incurred at each switching point, plus queuing delay at each switching point ( $T_{\text{queuing}}$ ), which is a function of how many other packets are attempting to use the same physical link at the same time.  $T_{\text{transmission}}$  and  $T_{\text{switching}}$  are essentially fixed values for a given packet route.

The invention is based on the realization that in effect the only variable is in fact  $T_{\text{queuing}}$ . Thus by measuring and storing over set time intervals the exact  $T_{\text{queuing}}$  at each switch for every packet of a connection where timing information is desired, applying statistical mathematics to the resulting values such as mean, variance and standard deviation, and summing up these values across the involved switches, then adding in  $T_{\text{transmission}}$  and  $T_{\text{switching}}$  values, an accurate statistical view of the delay encountered by packets of a connection can be realized.

This statistical view is equivalent to the information arrived at by using test packets, for although a test packet returns an actual delay value, several test packets must be sent to arrive at a true value since a single test packet cannot be trusted to be typical of delays encountered; similar statistical analysis of the test packets results must be done.

The invention will now be described in more detail, by way of example only, with reference to the accompanying drawings, in which the single Figure shows a packet switched network.

In the Figure, users 1, 2, are communicating over a virtual connection 2 established over a frame relay network 3 consisting of switch nodes A, B, C. The virtual connection is carried over physical links 4, 5.

As each packet traverses the virtual connection it encounters a transmission delay  $T_{\text{transmission}}$ , which is the time taken to traverse the physical links 4, 5, and a switching delay  $T_{\text{switching}}$ , which is a substantially constant delay incurred at each switching point. These values can be treated as constants that can be determined for each connection.

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$T_{\text{queing}}$ , for example at switch B, is calculated by using the line speed of the link 4 and the number of bytes of data in other frames that are using the physical link but are queued ahead of the frame in question. The switch is capable of knowing this information when it processes the frame. For example, a frame arrives at a switch after taking  $T_{\text{transmission}}$  to arrive from its previous location. This frame is switched inside the switch B taking  $T_{\text{switching}}$  time, and is queued to the physical link 5. Due to its arrival time (and other factors), the frame is behind 3 frames of identical length. It follows then that  $T_{\text{queing}}$  would equal  $3 * T_{\text{transmission}}$ , as the other frames must leave the switch before the target frame can use the physical link.

The total delay for this switch (or "hop") would be  $T_{\text{transmission}} + T_{\text{switching}} + T_{\text{queing}}$  where for this example  $T_{\text{queing}} = 3 * T_{\text{transmission}}$ . This value is stored in the switch for a given connection and for each frame switched on the connection the results are statistically added. By adding the statistical results from all switches involved in a connection path, the statistical delay encountered by frames on a connection is accurately measured.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE  
PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method of measuring packet delay in a packet switched network comprising the steps of:
  - a) measuring the queuing time for each packet at each node on a connection through the network;
  - b) applying statistical methods to determine a representative value at each node;
  - c) summing said representative values across the connection; and
  - d) adding to said summed representative values a value representing transmission delay and switching delay.
2. A method as claimed in claim 1, wherein the queuing delay of a connection is determined from the line speed of the link and the number of bytes of data from other packets that are using the physical link carrying said connection and are queued ahead of the packet in question.
3. A method as claimed in claim 2, wherein the queuing delay is stored in the associated node, and the delays incurred by each packet switched on the connection are statistically added.

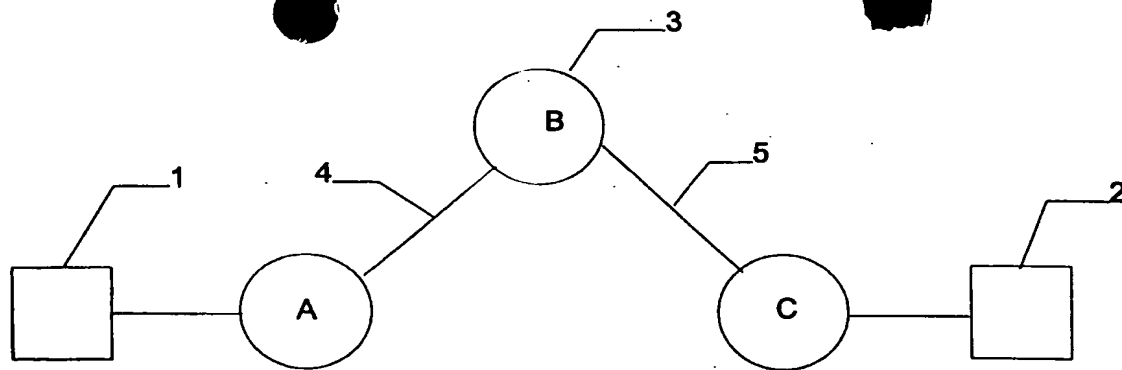


Figure 1

Mark & Ode